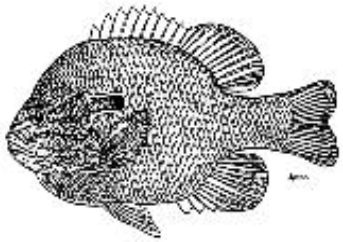
Investigation of the Surficial Sediment Depths of Walnut Creek, Kosciusko County Downstream of the Warsaw Wastewater Treatment Plant



Indiana Department of Environmental Management
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Investigation of the Surficial Sediment Depths of Walnut Creek, Kosciusko County Downstream of the Warsaw Wastewater Treatment Plant

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OFFICE OF WATER QUALITY
ASSESSMENT BRANCH
BIOLOGICAL STUDIES SECTION
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Abstract

The Biological Studies Section (BSS) was asked to conduct an instream study on Walnut Creek, downstream of the Warsaw, Indiana municipal wastewater treatment plant (WWTP) to examine the magnitude and extent of sediments covering the bottom of the creek. Walnut Creek discharges to the Tippecanoe River, 2,250 meters downstream of the WWTP. The BSS staff collected data over two days (December 16-17, 2002) within the zone of interest. Data were collected for 22-transects set at 100-meter intervals, starting at the Market St. bridge and continuing downstream to the confluence with the Tippecanoe River. Measurements included water depth, stream width and surficial sediment depths. Transect location was determined by hip tack lines and each site was flagged and geo-referenced using a global positioning system (GPS). Water depth and surficial sediment depth were determined using a measuring tape and a rod graduated in 0.20-meter increments. Field measurements were taken from the stream center and each quarter point toward each bank. Stream width was recorded to the nearest 0.5 meter. Sediment volume was calculated from these field measurements. Surface contour maps of the sediment deposits were also drawn. The average stream width through the reach was 14.2 meters. Average sediment depth at all cross section points was calculated to be 0.42 meters. The volume of sediment on the bottom of the creek, in the sampled reach was calculated to be 16,925 cubic meters (22,137 cubic yards or 4.5 million gallons in equivalency).

Introduction

The Biological Studies Section (BSS) was asked to conduct an instream study to examine the magnitude and extent of a sediment layer covering the bottom of Walnut Creek, Kosciusko County downstream of the Warsaw, Indiana wastewater treatment plant (WWTP). The BSS staff collected data over two days (December 16-17, 2002) within the zone of interest. Stream width was determined as well as quarter point water depths and surficial sediment depths at 100-meter intervals from the bridge above the WWTP (Market Street) to the mouth of Walnut Creek. Walnut Creek discharges to the Tippecanoe River, 2,250 meters downstream. A 1998 study ranked the Tippecanoe as the eighth most important river in the entire country for preserving imperiled aquatic species. The river supports 21 species of fish and mussels that are Endangered status. (Master, Lawrence; S.R. Flack and B. Stein, eds. 1998. Rivers of Life, Critical Watersheds for Protecting Freshwater Diversity, The Nature Conservancy, Arlington, Virginia.)

Methods

Data collection was done using a measuring tape and a calibrated rod marked in 0.20-meter increments. Location was determined by use of a hip tack line and the transects geo-referenced using a Garmin eTrex Vista ® global positioning system (GPS).

Measurements were taken manually by wading in the stream using a canoe as a support craft. Due to sediment blanket depth, downstream sites were accessed and measurements taken while working from the canoe. Sediment blanket depth was determined to be greater then 1.5 meters when the measuring device was not long enough to take a total measurement. A canoe paddle was used to confirm that the sediment layer was greater then 1.5 meters at these points. In those areas where water depth and sediment depth allowed, a firm sand gravel interface could be felt by use of the measuring rod. Stream width was recorded to the nearest 0.5 meter.

The field data were returned to the office and sediment volume was calculated. Surface contour maps and volumes were generated and calculated using Surfer 6.03, Surface Mapping System © by Golden Software, Inc. (1993-1996). Using the Nearest Neighbor method a matrix was generated from filed data with the number of lines calculated in the X and Y-axis being 247 and 115, respectively. This matrix was spline-smoothed adding ten (10) nodes between each column and row. A surface map was then generated from the spline-smoothed matrix. Volume was calculated from the spline-smoothed matrix using the Simpson's Rule. The lower surface was set to zero and the upper surface was the surface plot. Sediment depth was also presented as a smoothed spline projection using Statistica 6.0 ©, StatSoft, Inc 1984-2002.

The GPS readings were plotted on a 7.5-minute topographic map in Figure 1. The GPS readings were not differentially corrected in the laboratory but generally had a real time accuracy of about plus or minus 20-30 feet. An April 24, 1998 USGS aerial photograph of the WWTP and the wetland to the north are shown in Figure 2. The same aerial view is also included showing the course of Walnut Creek from the WWTP to the confluence with the Tippecanoe River (Figure 3). These images were take from the Mircrosoft TerraServer (http://terraserver.homeadvisor.msn.com).

Photographs of the Walnut Creek channel are presented in Figure 4. The difficulty of moving in the stream channel due to fallen timber, log jams, and solid waste is evident in these photographs. In addition, the heavy sediment blanket made walking in the channel increasingly more difficult as we moved downstream.

Results

By wading and the use of a canoe it was possible to collect data on the sediment blanket covering the bottom of Walnut Creek downstream of the Warsaw WWTP. Log jams and downed trees made movement difficult. The bottom of Walnut Creek upstream of Market Street and the WWTP were determined to be sediment free and both largemouth bass and suckers were observed. The bottom of the sediment free stream is sand gravel with very clear water and with the bottom visible at over 1.5 meters. Alochthonous input in the form of leaf packs, upstream of the WWTP, are typical to late season Indiana streams with a fresh de-compositional odor being presented when disturbed.

Data collected from the 22 transects on Walnut Creek are reported in Table 1. No fish were observed throughout the reach sampled. The average width of the stream through the reach was 14.2 meters. The average sediment depth at all cross section points was calculated to be 0.42 meters. The volume of sediment (Table 2), on the bottom of the creek was calculated to be 16,925 cubic meters (22,137 cubic yards or 4.5 million gallons in equivalency).

Three-dimensional projections of the sediment depth data are presented in Figures 5, 6 and 7. Figures 5 and 6 were generated using Surfer 6.03© and Figure 7 was created using Statistica©. Figure 5 is oriented as if standing on the left descending bank looking upstream and downstream.
Figure 6 is oriented as if standing on the right descending bank looking upstream and downstream. The sediment blanket in Figure 6 can be viewed clinging to the right descending bank edge. A smoothed spline projection of the data is presented in Figure 7 for comparison.

The IDEM Fixed Site 1 (at Fox Farm Road) on the Tippecanoe River, approximately 0.5 kilometers (km) upstream of the mouth of Walnut Creek, Fixed Site 2 (Behind Hartzler St. about 0.9 km downstream of the Walnut Creek confluence) and Site 3 (County Road 350 W., approximately 2.9 km downstream of the confluence) were examined for water chemistry. These data were collected in August of 2002, by the OWQ Survey Section staff. Preliminary investigation of the August chemistry data of the Tippecanoe River upstream and downstream of the mouth of Walnut Creek indicate sharp elevations in Total Organic Carbon (TOC), Total Kjeldahl Nitrogen (TKN), Total Phosphorus, Nitrogen (Nitrate+Nitrite), Nitrogen (Ammonia) and Chlorides downstream of the mouth of Walnut Creek (Appendix A).

Field data collected at the Tippecanoe River sites (August 7-29, 2002) compared to that of Walnut Creek suggests that Walnut Creek significantly reduced dissolved oxygen in the Tippecanoe River during August 2002. Mean dissolved oxygen, on these dates, at Fox Run (upstream mouth of Walnut Creek) was 8.83 mg/l (92.5% saturation). The two downstream sites (Hartzler St and CR 350 W.) were 4.19 mg/l (47.8% saturation) and 4.12 mg/l (48.9% saturation) respectively. A Mann-Whitney U Test indicated that the Tippecanoe River sites downstream of the Walnut Creek confluence were statistically lower in dissolved oxygen and percent saturation than the Tippecanoe River sites upstream of the confluence. (" =0.05, d.f.=3). In addition Walnut Creek caused the two downstream Tippecanoe

River sites to drop below the State water quality minimum of 4 mg/l on 50% of these occasions. The combined field sampling on Walnut Creek, downstream of the Warsaw WWTP over the same period indicated a mean dissolved oxygen of 4.87 mg/l with a mean percent saturation of 57.3 which is statistically the same as the 2 downstream Tippecanoe sites. The instream un-ionized ammonia standard of 2.17 mg/l was exceeded in Walnut Creek by over 200% with average ammonia of 4.55 mg/l

Conclusions

The bottom of Walnut Creek downstream of the Warsaw WWTP is covered by a thick layer of what appears to be WWTP sludge. This is based on the physical appearance and particularly the odor of the settleable solids. The last 1.75 kilometers of the downstream area of Walnut Creek appeared to be severely impaired physically, chemically and biologically due to this sludge blanket. The volume of sludge was calculated to be greater then 16,925 cubic meters (22,137 cubic yards or 4.5 million gallons in equivalency). It is anticipated that severe oxygen depletion would occur in this area particularly in the summer months. No fish were observed throughout the sampled area even though fish were observed above the WWTP. An ambient fish community assessment should be conducted above and below the WWTP including samples upstream and downstream of the mouth on the Tippecanoe River.

We suggest that chemical characterizations of this sludge blanket occur, and the source and means of stream entry be investigated. The stream-bottom in the area immediately below the Combined Sewer Overflow (CSO) on the upstream side of Market street does not suggest that the sludge is entering the stream, at this time or in recent times, from this point. The stream bottom immediately downstream of the WWTP outfall would also suggest that the sludge has not recently entered the stream from this point. The sludge blanket appears to become significant at a point 500 meters downstream of the Market Street Bridge at a low spot on the right descending bank. The possibility of the sludge coming from (or entering) the extensive wetland to the north of the WWTP on the east bank should be investigated. One possible method to make this determination would be the use of sediment coring and chemical analysis, comparing the wetland sediments to the sediments in the stream.

Preliminary chemical investigation of the August chemistry data of the Tippecanoe River upstream and downstream of the mouth of Walnut Creek indicate significant elevations in TOC; TKN; Total Phosphorus; Nitrogen, Nitrate+Nitrite; Nitrogen as Ammonia; and Chlorides (Appendix A). These data would preliminarily indicate that Walnut Creek is causing a significant increase in nutrients going to the Tippecanoe River. Violations of the State minimum water quality standards were noted for un-ionized ammonia in Walnut Creek and statistically significant lowering of oxygen concentrations in both Walnut Creek and the Tippecanoe River for at least two sites below the mouth of Walnut Creek. A daily chemical-monitoring program upstream and downstream of the mouth of Walnut Creek is recommended.

Walnut Creek is a tributary of the Tippecanoe River, one of the most important streams in Indiana and in the nation for the protection of rare and endangered aquatic organisms. This sediment and the associated nutrients threaten the critical aquatic downstream resources of the Tippecanoe River (including two public reservoirs) as they are flushed out of Walnut Creek. Engineering solutions to remediate and remove this sediment from the natural sand-gravel bottom of Walnut Creek should be investigated.

Figure 1: Location of Transects as Determined by GPS

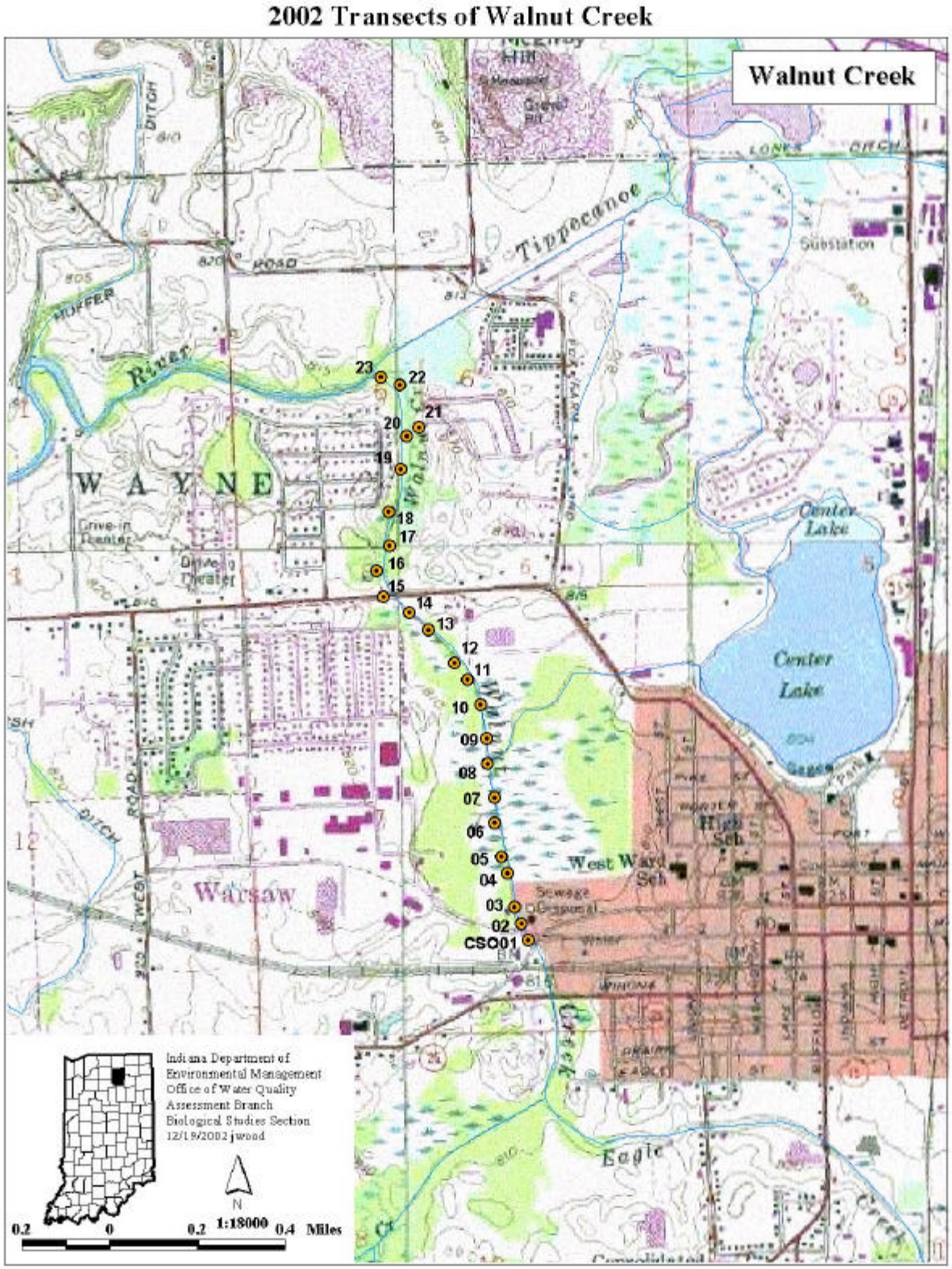


Figure 2: April 1998 Aerial Photograph of Warsaw, Indiana
Close up of Wetlands North of the WWTP

Figure 3: April 1998 Aerial Photograph of Warsaw, Indiana
Walnut Creek from WWTP to Confluence with Tippecanoe River

Figure 4: Photographs of Walnut Creek

Table 1: Field Measurements of Water Depth and Sediment Depth

Location	Stream Width meters	Right Descending Bank (RDB) Water Depth (Sediment Depth) meters	Stream Center Water Depth (Sediment Depth) meters	Left Descending Bank (LDB) Water Depth (Sediment Depth) meters
CSO Above Brg				
Transect 2	9.0	0.34 (trace)	0.58 (trace)	0.48 (trace)
Transect 3	12.7	0.12 (trace)	0.14 (trace)	0.30 (trace)
Transect 4	12.5	0.32 (dust)	0.34 (dust)	0.50 (dust)
Transect 5	13.5	0.42 (dust)	0.32 (dust)	0.50 (dust)
Transect 6	17.0	0.30 (0.20)	0.28 (0)	0.40 (dust)
Transect 7	16.0	0.10 (0.50)	0.20 (0)	0.30 (0)
Transect 8	14.0	0.30 (1.20)	0.26 (0.20)	0.50 (0.50)
Transect 9	14.0	0.30 (0.50)	0.40 (0.50)	0.5 (0.10)
Transect 10	12.0	0.50 (>0.80)	0.70 (>0.70)	0.70 (>0.70)
Transect 11	13.0	0.40 (0.25)	0.50 (0.20)	0.30 (0.20)
Transect 12	13.0	0.60 (0.16)	0.60 (0.70)	0.48 (0.92)
Transect 13	13.0	0.80 (0.70)	0.80 (0.20)	0.68 (0.82)
Transect 14	12.0	0.80 (0.10)	0.90 (>0.60)	0.72 (>0.78)
Transect 15	11.0	0.70 (0.10)	0.90 (0.40)	0.58 (0.10)
Transect 16	14.0	0.60 (>0.90)*	0.80 (>0.70)*	0.50 (0.20)
Transect 17	15.0	0.50 (>1.00)*	0.70 (>0.80)*	0.80 (0.30)
Transect 18	19.0	0.50 (>1.00)*	0.60 (>1.00)*	0.88 (>1.00)
Transect 19	16.5	1.00 (>1.30)*	0.70 (>1.50)*	0.60 (0.45)
Transect 20	15.0	1.12 (>1.50)*	0.90 (>1.50)*	0.82 (>1.50)*
Transect 21	16.0	1.8 (>0.30)*	1.00 (>0.50)*	0.90 (>0.60)*
Transect 22	17.0	0.80 (>0.70)*	1.10 (>0.40)*	0.90 (>0.60)*
Transect 23	16.5	1.40 (>1.50)*	---	1.00 (>1.50)*
* Sediment determined to be >1.5 m for calculation purposes				

Table 2: Sediment Volume Calculations

VOLUME COMPUTATIONS

UPPER SURFACE
Grid File: C:/MY DOCUMENTS/OUT.GRD
Grid size as read: 247 cols by 115 rows
Delta X: 9.14634
Delta Y: 0.402793
X-Range: 0 to 2250
Y-Range: -22.9592 to 22.9592
Z-Range: -0.288876 to 1.82739

LOWER SURFACE
Level Surface defined by Z = 0

VOLUMES
Approximated Volume by
Trapezoidal Rule: 16919.8
Simpson's Rule: 16925.1
Simpson's 3/8 Rule: 16919.8

CUT & FILL VOLUMES
Positive Volume [Cut]: 17162.8
Negative Volume [Fill]: 243.025
Cut minus Fill: 16919.8

AREAS
Positive Planar Area
(Upper above Lower): 60362.2
Negative Planar Area
(Lower above Upper): 42954.2
Blanked Planar Area: 0
Total Planar Area: 103316

Positive Surface Area
(Upper above Lower): 61906
Negative Surface Area
(Lower above Upper): 43033.2

<u>Sludge Volumes</u>

16,925 meter ^{3}

= 22,137 yards ^{3}

= 4,500,000 gallons

Figure 5: Cross Section of Sediment Depth (Left Descending Bank View)

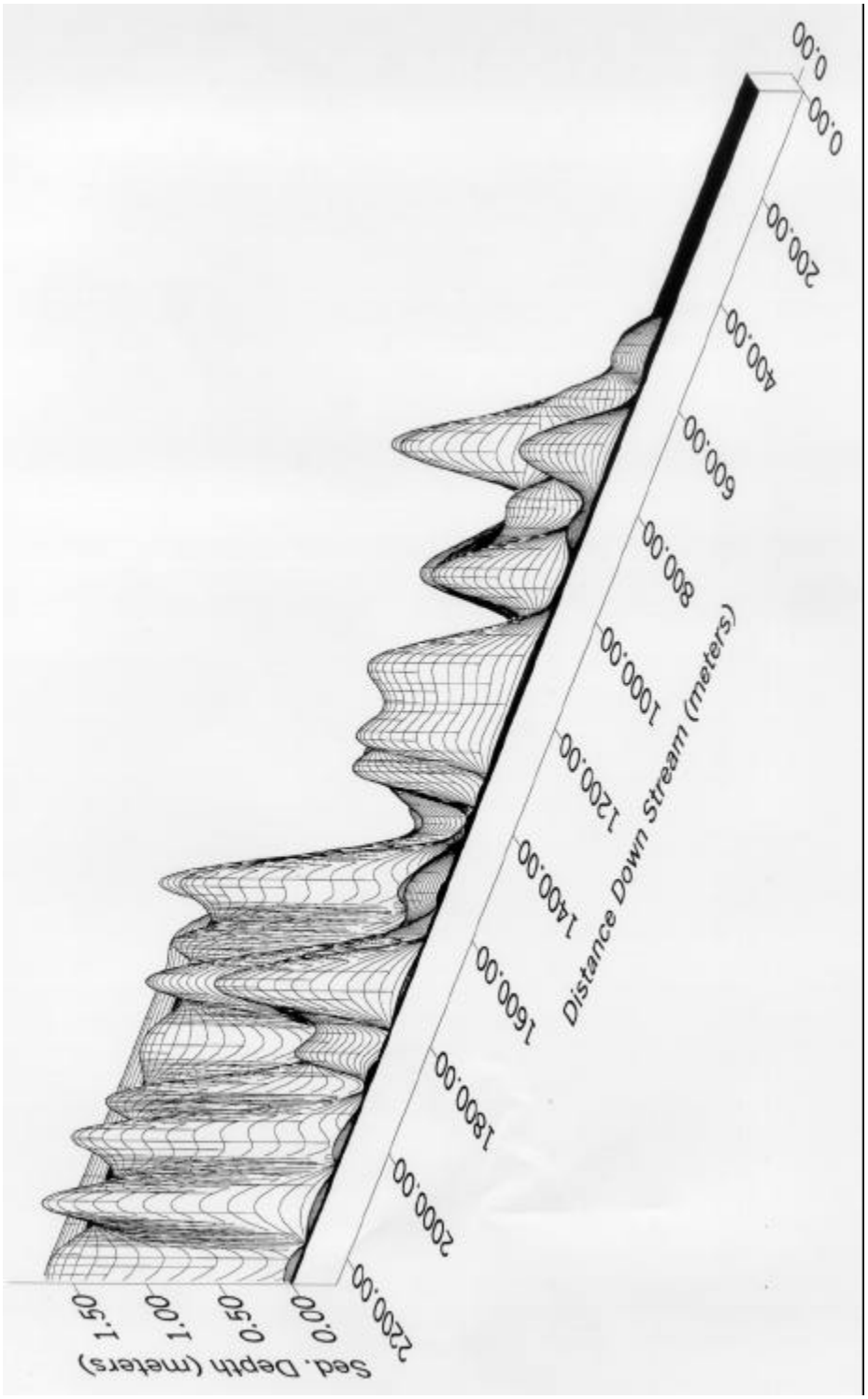


Figure 6: Cross Section of Sediment Depth (Right Descending Bank View)

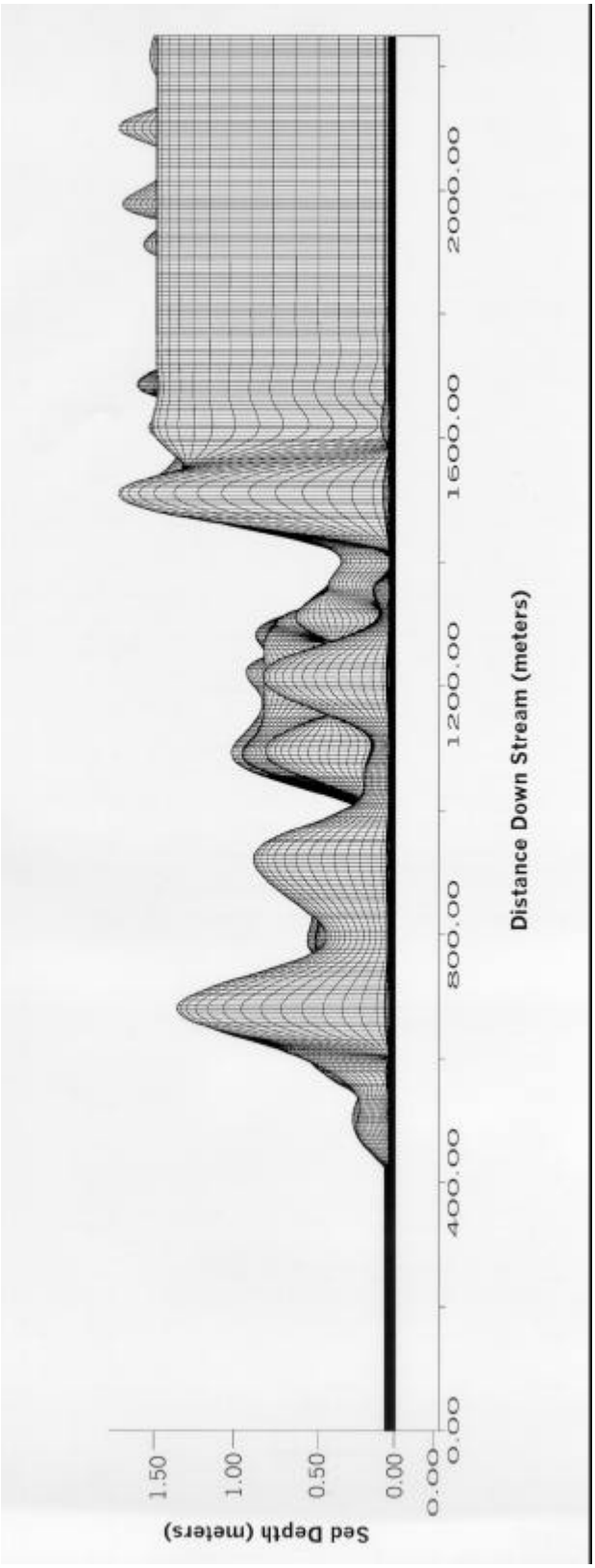
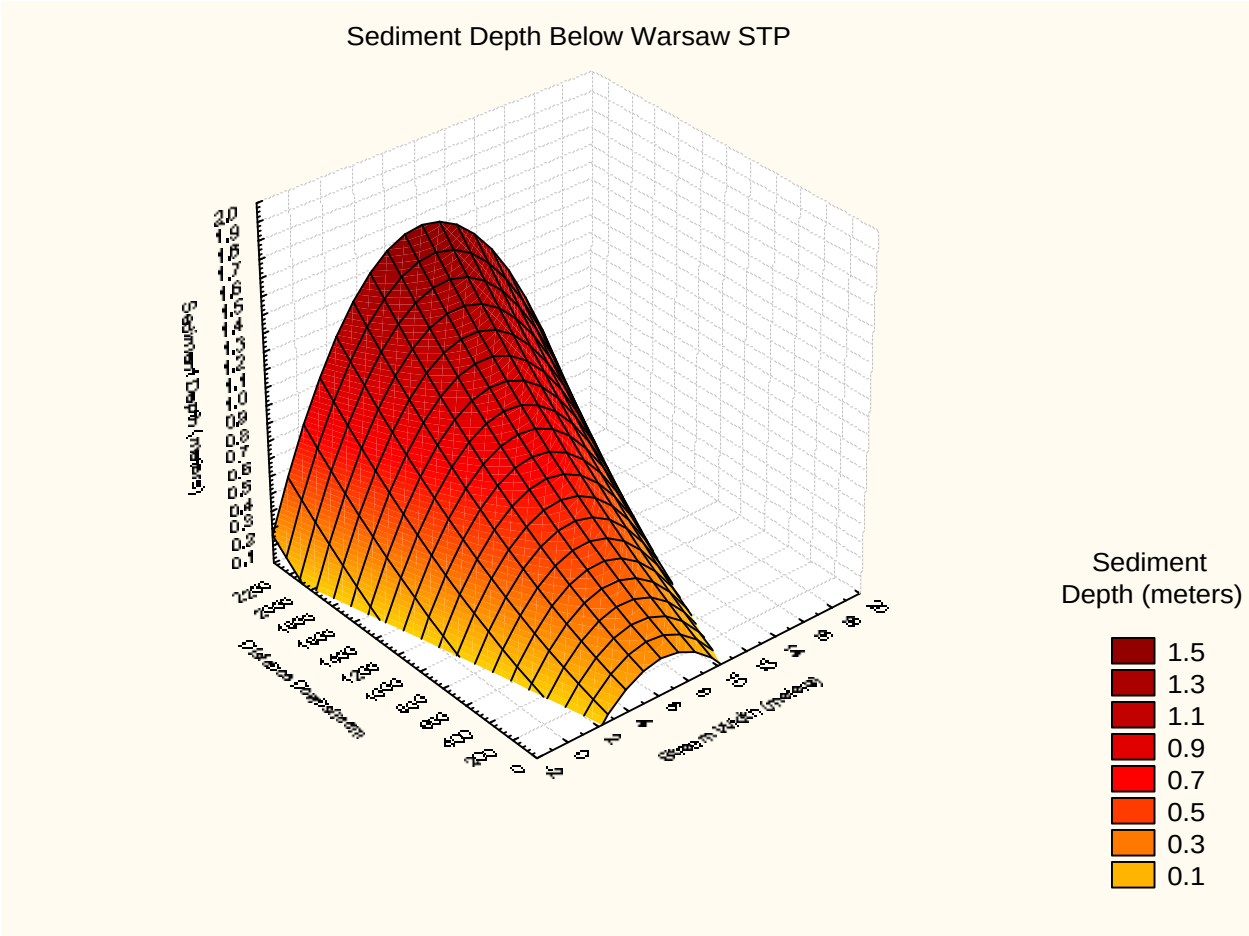
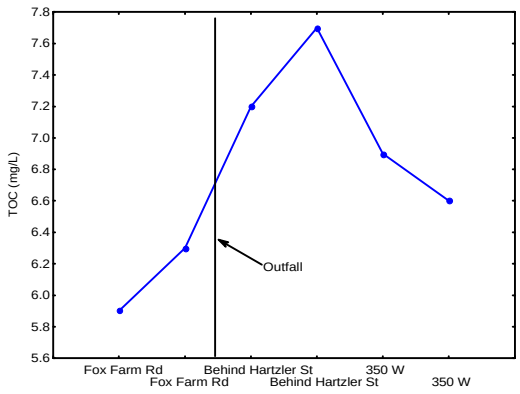


Figure 7: Spline Presentation of Sediment Depths



Appendix A: August 2002 Water Chemistry Upstream and Downstream of Mouth of Walnut Creek On the Tippecanoe River, Kosciusko County



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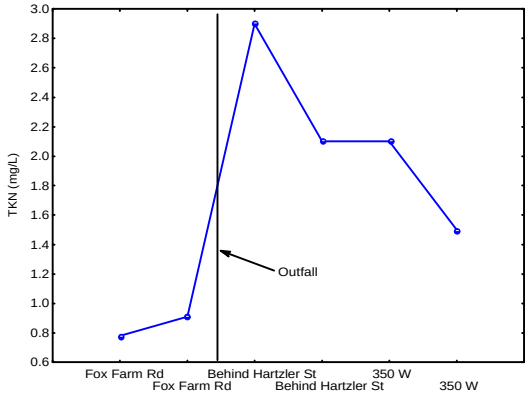

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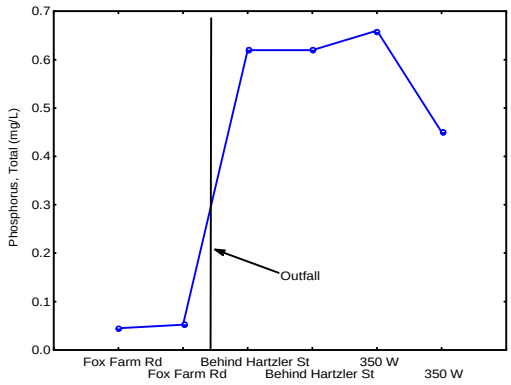

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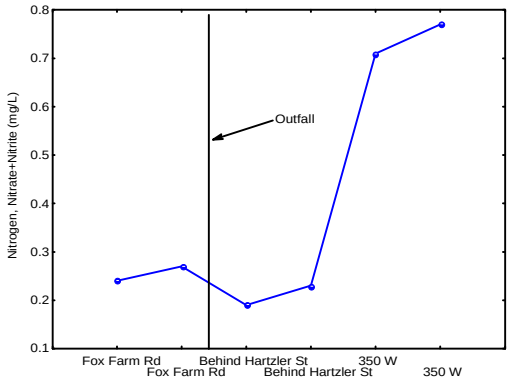

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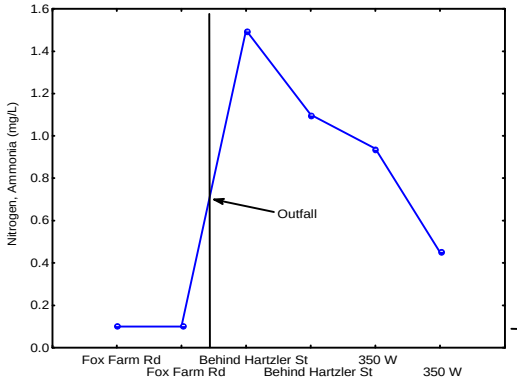

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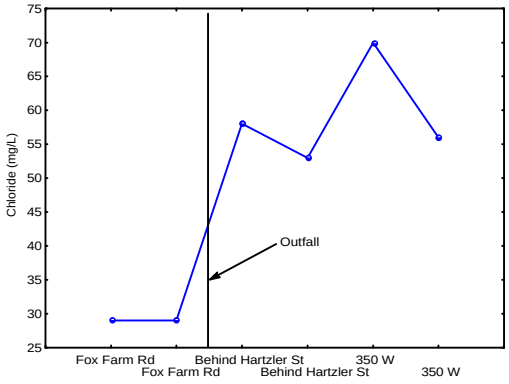

F

Graphs of **A)** TOC **B)** TKN **C)** Total Phosphorus **D)** Nitrogen, Nitrate+Nitrite (mg/L) **E)** Nitrogen, Ammonia (mg/L), and **F)** Chloride (mg/L) collected from fixed station locations both upstream and downstream of the confluence of Walnut Creek and the Tippecanoe River in August 2002. The vertical bar denotes relative placement of the confluence in relation to sampling locations. Fixed site 1 (Fox Farm Road) is located on the Tippecanoe River approximately 0.5 km upstream of the confluence with Walnut Creek. Site 2 (Behind Hartzler St.) is located approximately 0.9 km downstream of the Walnut creek confluence, and site 3 (350 W) is located 2.9 km downstream of the confluence.

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Biological Studies Section
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